Wood pellet firing for steam locomotives

Background:
Due to the coal phase-out and other boundary conditions, it is becoming increasingly difficult to procure high-quality locomotive coal on the world market. Coal, which is already very expensive, is becoming even more expensive due to CO_2-taxation. Various environmental discussions are also increasingly leading to criticism. Wood pellets are the most promising alternative fuel for grate firing. Their practical applicability, even for high performance requirements, has been confirmed in a research project funded by the Deutsche Bundesstiftung Umwelt (German Federal Environmental Foundation).

The substitute fuel:
Certified wood pellets are produced from sawmill by-products - i.e. residual materials - in consistent, standardised quality and are not subject to energy or CO_2-taxes. The fuel is clean, low in dust and ash (max. 0.7%), but must be stored dry and properly. At 4.9 kWh/kg, the calorific value is about 60% of that of high-quality hard coal, which is equivalent to lignite briquettes. This results in higher consumption. Established for building heating and industrial firing, large quantities are regionally available as bagged goods, in BigBags or by silo truck. Unlike coal, wood generally needs most of the combustion air fed above the firebed as secondary air.

What measures are necessary for conversion?

- Fuel storage protected from the weather (e.g. in wagons, sacks or silos).
- Bunkering protected from rain (e.g. shelter, tarpaulin, automatic conveyance through pipe)
- Fuel bunker must be covered in appropriate weather conditions (protection from rain).
- Fire grate must be replaced
- Adjustments to fire door and draught system may be necessary
- Long fire brick arch at the appropriate angle required
- Carefully designed secondary air supply to the firebox
- Adjustment of spark arrester

Is this a type change?

No. In contrast to conversion to oil firing, the type of design (grate firing) remains the same and the boiler itself remains untouched. Nevertheless, it is advisable to inform the responsible boiler expert and the supervisory authority at an early stage of any planned conversion and to agree on modifications.

Is there a loss of performance?

Tests have confirmed that the nominal boiler output of normally dimensioned boilers (grate load for coal firing 400 - 450 kg/m²h) is safely achieved as a continuous output. This also applies to small fireboxes without combustion chambers, whereby these and large grate areas are advantageous. The continuous output can be maintained more easily and for longer, as the fire does not become slagged over time.

Consumption and range:

As the load increases, the boiler works noticeably more efficiently with wood pellet firing than with coal firing due to the lack of flying loss and clean combustion, which reduces consumption. Depending on the load, the additional consumption is around 30 - 80, on average around 50 %. The range with a bunker filling is reduced by this and due to the lower density accordingly - on average to 60 % of the original. The better the locomotive's power output is utilised, the more favourable the values are.

Do pellets make sense for small boilers and low output requirements?
For occasional, field operation and/or stationary applications with very low boiler outputs, lump wood or wood briquette is more suitable.

What has to be considered for boiler operation and firing?
Fire build-up and output adjustments are very fast. However, it is hardly possible to build up reserves in the fire, so that firing must take place at shorter intervals. As with oil firing, the fireman must pay close attention. The fire should be fed evenly and not with too much fuel at once. Classic rest firing is not possible, but with an insulated boiler it is not necessary either, as a new fire can be lit very quickly.

Feasible with hand firing?
For occasional operation and for moderately large grate areas, classic hand firing is justifiable. The additional load on the fireman is not necessarily due to the higher consumption, but to the shorter firing intervals. Under load, the shovel must be used every 2 minutes at the latest. The golden rule "little and often" applies especially to pellets. For higher demands and large grate areas, mechanical firing is the way to go.

Open fire door = boiler damage?
Carefully designed air ducting prevents the incoming secondary air from reaching boiler walls. Temperature measurements have shown that the firebox is thermally less and more evenly loaded than with coal firing. In the case of the test locomotive, the temperature at the firebox tube wall even drops when the fire door is closed.

Are there any disadvantages for boiler operation and maintenance?
On the contrary: wood pellets are practically sulphur-free, burn with little soot and leave hardly any combustion residues. Heating surfaces, ash pan, smoke box and the entire train need to be cleaned much less frequently.

Wood fire = flying sparks?
If the air is directed correctly, only very few sparks are produced, as the air flow through the fire bed is greatly restricted. For additional safety, a spark arrester with a mesh size of 1.6 mm is installed. The risk is therefore even lower than with coal firing.

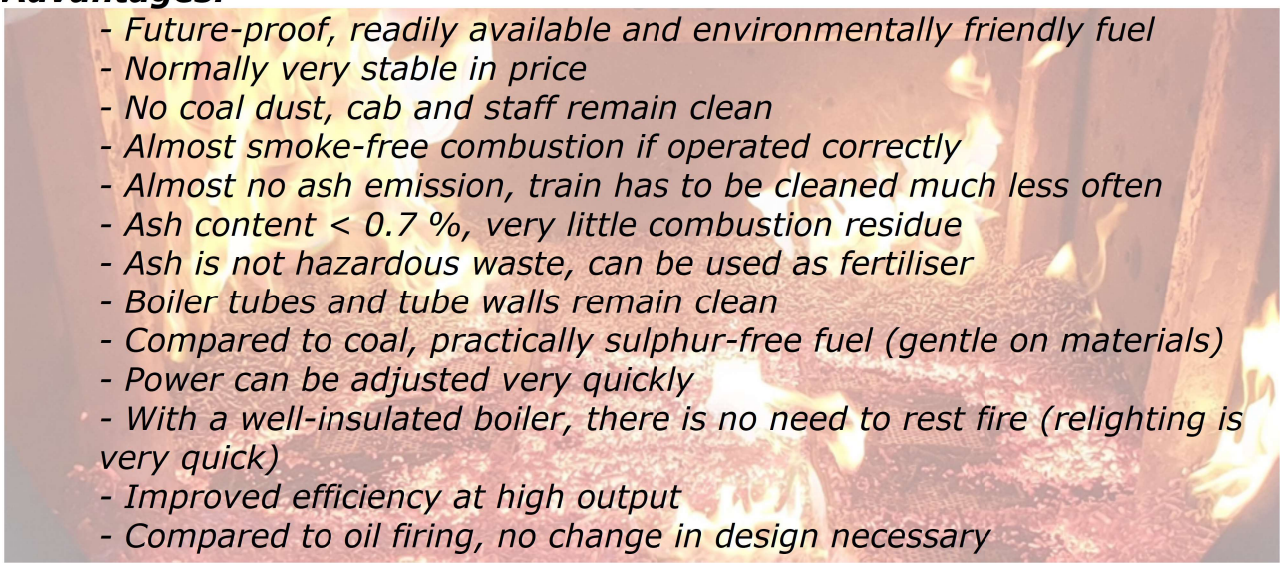
Conversion and operating costs:
The careful design and calculation of the components - individually for each locomotive series - is decisive for successful long-term operation. A test run is also recommended for fine-tuning. In addition, the material costs - depending on the personal contribution - are usually < 10,000 €, while retaining hand firing. A wide range of subsidies are also available for such conversion projects.

Overview:

Disadvantages:

- More frequent firing, less time for track observation (with manual firing)
- Range reduced
- Firing requires more attention of the fireman
- Fuel must be stored in a dry place
- Smell of poor combustion is more unpleasant than with coal
- Requires (manageable) conversion work

Advantages:



- Future-proof, readily available and environmentally friendly fuel
- Normally very stable in price
- No coal dust, cab and staff remain clean
- Almost smoke-free combustion if operated correctly
- Almost no ash emission, train has to be cleaned much less often
- Ash content < 0.7 %, very little combustion residue
- Ash is not hazardous waste, can be used as fertiliser
- Boiler tubes and tube walls remain clean
- Compared to coal, practically sulphur-free fuel (gentle on materials)
- Power can be adjusted very quickly
- With a well-insulated boiler, there is no need to rest fire (relighting is very quick)
- Improved efficiency at high output
- Compared to oil firing, no change in design necessary